

# ***P*-velocity of the upper mantle**

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Received 2 December 2020

The authors have constructed models featuring seismic *P*-wave velocity distribution in the upper mantle beneath oceanic, continental and transition regions, such as mid-ocean ridges, basins, trenches, island arcs, and back-arc troughs, Atlantic transitional zones, flanking plateaus of mid-ocean ridges, platforms, geosynclines, rifts, recent activation zones. The models are in agreement with the deep-seated processes in the tectonosphere as predicted in terms of the advection-polymorphism hypothesis. The models for areas of island arcs and coastal ridges are similar to those for alpine geosynclines disturbed by recent activation. The models for areas of mid-ocean ridges and back-arc troughs are identical. They fit the pattern of recent heat-and-mass transfer in the case of rifting, which, given the basic crust with continental thickness, leads to oceanization. The model for the basin reflects the effect of thermal anomalies smoothing beneath mid-ocean ridges or back-arc troughs about 60 million years later. The model for the trench and flanking plateau reflects the result of lateral heating of the mantle's upper layers beneath the quiescent block from the direction of the island arc and basin (trench) and mid-ocean ridge and basin (flanking plateau).

A detailed bibliography on regions covered by studies was presented in the authors' earlier publications over past eight years. There are quite significant differences between models for regions of the same type that are described in publications of other authors. This is largely due to the fact that individual authors adopt a priori concepts on the velocity structure of the upper mantle.

High variability of seismic *P*-wave velocities within the subsurface depth interval has been detected as a result of all sufficiently detailed studies. This variability is responsible for the sharp increase in the scatter of arrival times of waves from earthquakes at small angular distances. The corresponding segments of travel-time graphs were simply ignored, and the graphs started from about 3° after which the scatter of arrival time acquired a stable character. Accordingly, velocity profiles were constructed, as a rule, starting from depths of about 50 km. The constructed velocity profiles vary little from region to region with the same type of endogenous regimes. This enables us to maintain that the models represent standard (typical)  $V_p$  distributions in the mantle beneath the regions, just as presumed in terms of the theory.

**Key words:** oceans, continents, transition regions, upper mantle, velocity models.

**Introduction.** A generalization of the geological and geophysical information pertaining to continents, oceans and ocean-to-continent transition zones that was performed, in particular, by [Gordienko, 2010, 2012, 2015 and others], reveals that the said information is insufficient to ensure well-grounded verification of hypothetical schemes of the deep-seated processes in the tectonosphere of the regions in question. In this specific case, we

are talking about schemes conforming to the advection-polymorphism hypothesis. The situation may be rectified, to a certain extent, with the help of velocity models constructed for the upper mantle beneath those regions, which are known for their often elevated seismicity and are equipped with a rather extensive earthquake monitoring system. Even the construction of one-dimensional *P*-wave velocity ( $V_p$ ) distribution with depth, although not

reflecting sufficient detail, could enable us to gain insight into the main patterns of heat-and-mass transfer in the upper mantle ridges (MOR), oceanic basins, deep-water trenches, island arcs (in these authors' opinion, also co-astal ridges as their equivalent. Of particularly great interest would be a comprehensive set of such models for seismically unstable mid-ocean ridges and back-arc troughs (BAT), alpine rifts and geosynclines, platforms and zones of recent activation.

Velocity profiles constructed for many such regions have been reported in publications, but that information tends to be inconsistent (see below) or is limited to a priori concepts, such as, for example, on the absence of velocity variations with regard to the AK135 model [Gudmundsson, Sambridge, 1998 and others] at depths of the upper mantle's lower portion, and so on.

The most promising, in our opinion, is an operation being planned for island arcs, alpine rifts and geosynclines with the use of particularly dense seismic observation networks. Hypocenters of many earthquakes beneath territories and off-shore expanses in those regions are located at relatively shallow depths in the mantle's upper horizons. They may provide valuable material for the constructions being planned. Yet, we are also aware of possible complications due to the extremely irregular distribution of seismic wave velocities in the subcrustal portion of the tectonosphere [Nizkous et al., 2006 and others]. Despite these reservations, however, the goal may still be achieved.

In the authors' opinion, island arcs are not oceanic formations proper: They are Alpine geosynclines similar to those on continents. This conclusion is also corroborated by seismological data [Gordienko, 2016 and others]. Yet, the arcs are part of a system of structures in the active zone of continent-to-ocean transition. Back-arc troughs are often located closer to the continent and their crust is in a state of nearly complete oceanization. For that reason we added island arcs to the list of regions separately to be explored. After we study them and gain experience, it will be easier to proceed to the construction of mantle models for other regions.

We have constructed models featuring seismic *P*-wave velocity distribution in the upper mantle beneath oceanic, continental and transition regions, such as mid-ocean ridges (MOR), basins, trenches, island arcs, and back-arc troughs (BAT), atlantic transitional zones, flanking plateaus (FP) of MORs, platforms, geosynclines, rifts, recent activation zones.

A detailed bibliography on regions covered by studies was presented in the authors' earlier publications over past eight years [Gordienko, Gordienko, 2012, 2015a, b, 2016a—c, 2017a, b, 2018a, 2020a, b, 2021; Gordienko et al., 2020 and others].

**A priori data on velocity profiles for the upper mantle.** Continents, oceans and active margins have been covered fairly well by seismological studies [Fukao, 1977; Gudmundsson, Sambridge, 1988; Sergeev et al., 1992; Kennett et al., 1995; Pavlenkova et al., 1993; Pavlenkova, Pavlenkova, 2006; Walck, 1985; Zhao et al., 1999; Hansen, Ratchkovski, 2001; Romanowicz, 2003; Gontovaya, Gordienko, 2006; Feng et al., 2007; Jiang et al., 2009; Chu et al., 2012 and others]. There are, however, quite significant differences between models for regions of the same type that are described in the publications listed above. This is largely due to the fact that individual authors adopt a priori concepts on the velocity structure of the upper mantle. For a geological interpretation of velocity profiles to be accurate, they must be presented in absolute values of  $V_p$ . For that reason, we ignored models based on anomalous values if the authors failed to provide information on the relevant profiles.

Two groups of models can be identified: The first group always displays a sharp velocity contrast at a depth of about 400 km; this element is absent from the second group (Fig. 1).

Our data represent an average for several profiles; an average value plus-minus an average deviation from it are shown for each depth. Information for different regions varies depending on the number of models used, and we cannot claim that we have reviewed all the available data. It is rather a matter of detecting prevalent trends. The average va-

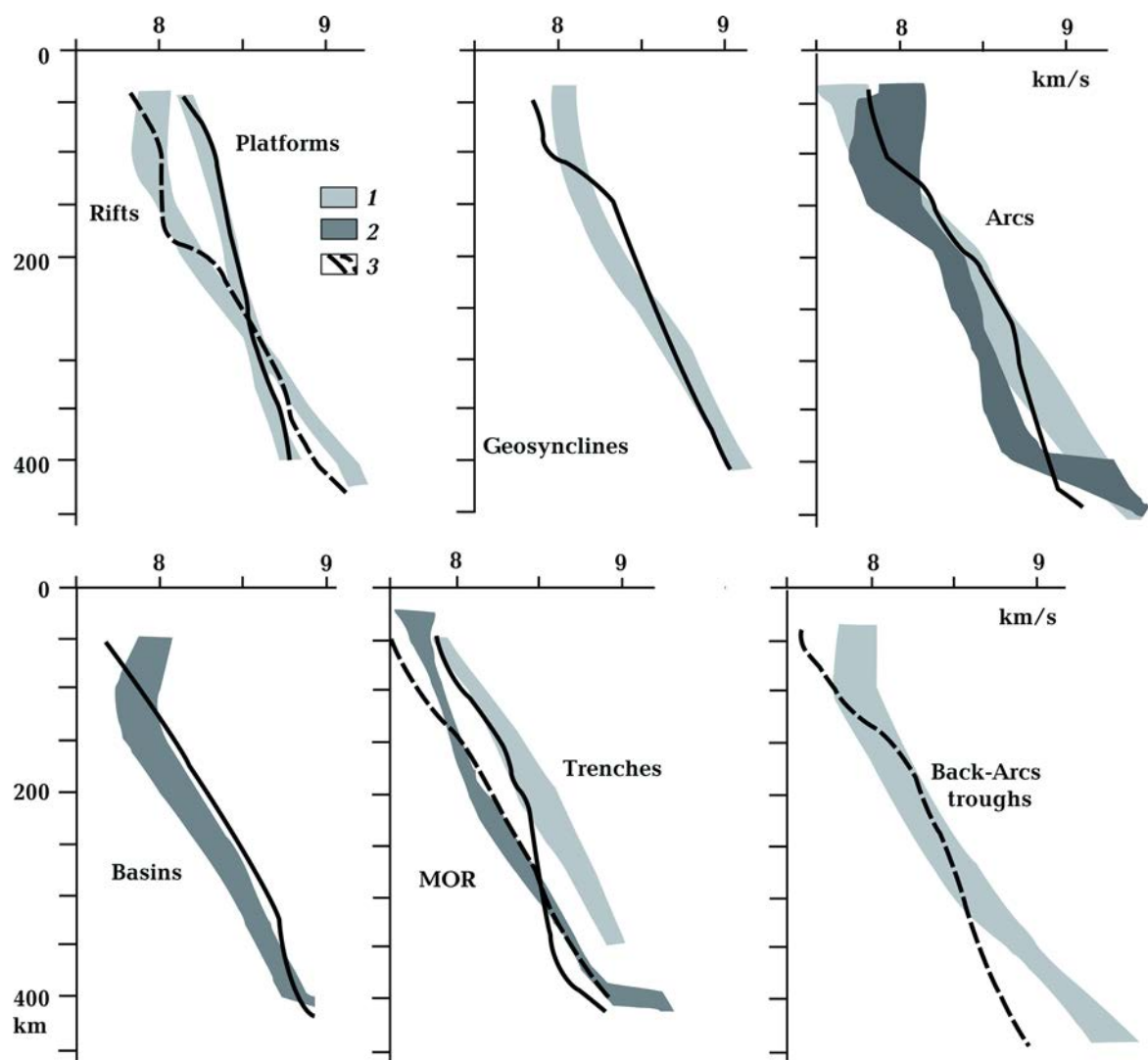


Fig. 1. Velocity models for regions with different endogenous regimes: 1 — without a surge in  $V_p$  at the depth of about 400 km; 2 — with a surge in  $V_p$ ; 3 — velocity profiles for the upper mantle estimated (in accordance with advection-polymorphism hypothesis — APH).

lues preset for all depths in the upper mantle beneath regions are fairly similar. Therefore, in selecting an estimated travel-time graph matching observed ones, it is possible to use a single first-approximation model.

Apart from seismic data, petrological data too, in particular those obtained by A. Ringwood [1981], provide a substantiation for placing an interface at the depth of 410 km. This depth is not infrequently incorporated a priori into velocity models for the mantle. The petrological evidence points to the beginning of a polymorphic transformation of mantle rocks at approximately that depth (at the tempera-

ture of about 1,600 °C). Taking into account the hypothetical composition of the olivine undergoing transformation, it has to be assumed that the process spreads over a considerable depth interval (the  $PT$ -conditions). According to estimates [Brown, Shankland, 1981; Irifune, 1987 and others], based on experimental data, the thickness of the layer, in which olivine- $\alpha$  transforms into modified spinel (olivine- $\beta$ ) and the transition of pyroxenes into garnets is completed, amounts to about 60 km. A. Ringwood's estimate is 100 km, but in his interpretation it is apparently a depth range for two transitions culminating in the formation of olivine- $\gamma$

(specifically, spinel with olivine composition).

The value of the vertical temperature gradient used in the evaluation of the depth of the polymorphic transition appears to be close to the actual gradient, but the quoted absolute temperature ( $T$ ) values and the technique used for their determination [Brown, Shankland, 1981; Ringwood, 1981] are at variance with our thermal models for the upper mantle [Gordienko, 2012, 2015 and others]. The very fact of the aforementioned dissimilar velocity profiles being recorded in the same region shows that it is impossible to get an unambiguous solution to the inverse geophysical problem given dissimilar approaches resorted to by different authors. Researchers who studied this specific issue [Zhao et al., 1999, for example], point out that seismic evidence can be made consistent with dissimilar  $V_p$  patterns within the depth interval in question. The depth of the velocity contrast in the models in question has been assumed to equal approximately 400 km. At the same time, studies conducted with the specific goal of determining that depth (i. e., under the assumption that the interface exists), suggest a depth of about 430 km or somewhat larger [Flanagan, Shearer, 1999; Pavlenkova, Pavlenkova, 2006].

The reliability of such information improves with an increase in detail and accuracy of accounting for the overlying strata [Melbourne, Helmberger, 1998; Flanagan, Shearer, 1999], but in practical terms, the depth variations (about 10 km) are smaller than the errors in their determination (about 15 km). From this perspective, it might be useful to compare obtained results with the data of deep seismic probing on the basis of nuclear explosions in Northern Eurasia [Pavlenkova, Pavlenkova, 2006]. In this case, the interface imaging technique enables us to make the most of the information on velocities in the crust and upper mantle. The depths, as determined by the two methods, coincide with an accuracy of up to a few kilometers.

Thus, the depth at which polymorphic transition most probably started must be about 430—435 km. This result is also in close agreement with that established with the help of a thermal model for the upper mantle

beneath a quiescent platform. At somewhat larger depths, the velocity must increase with a larger gradient, but not discontinuously.

The study [Gordienko, 2018] has shown an approximate match between the depths for the transition zone top in various continental regions as derived from experimental and estimated data. As far as oceans are concerned, the situation remains uncertain due to differences between the experimental data as reported by different authors. For that reason, we largely limited our modeling to the upper mantle.

Our crustal model (for island and continent seismic stations) was based on the data from publications [Belyaevsky, 1981; Udintsev, 1987; Pavlenkova et al., 1993; Pavlenkova, Pavlenkova, 2006; Sergeev et al., 1992; Olsen, 1995; Monney et al., 2002; Nizkous et al., 2006; Erlikh, 2011 and others]. Crustal thickness in first-approximation models is limited to 10—40 km. It goes without saying that the adopted crustal thickness and velocity structure are the result of a compromise between the data reported by different authors. In some specific regions, certain corrections were introduced to the structure without affecting results of the calculation in any appreciable manner. The aforementioned high variability of seismic  $P$ -wave velocities within the subsurface depth interval has been detected as a result of all sufficiently detailed studies [Pavlenkova et al., 1993; Nizkous et al., 2006 and others]. The aforementioned high variability is responsible for the sharp increase in the scatter of arrival times of waves from earthquakes at small angular distances. The corresponding segments of travel-time graphs were simply ignored, and the graphs started from about  $3^\circ$  after which the scatter of arrival time acquired a stable character. Accordingly, velocity profiles were constructed, as a rule, starting from depths of about 50 km.

**Factual evidence used.** Tectonic classification of oceans and active margins is often based on an adopted hypothesis regarding deep-seated processes. In view of the extremely limited information on the geological history of oceans, the authors tried to avoid such an approach. In most cases, we used purely

morphological indications and information on recent seismicity. Upheavals accompanied by earthquakes were attributed to mid-ocean ridges; vast basins were classified as regions of the same type regardless of local topography or manifestations of recent magmatic activity that complicate the general picture; marginal trenches and BATs were identified according to the sharp variation of depths. Island arcs and coastal ridges of Kamchatka, as well as of Northern, Central, and Southern Americas constituted an exception. They were viewed as undergoing the very beginning of the postgeosynclinal stage of evolution, in many cases complicated by recent activation [Gordienko, 2012, Gordienko, Gordienko, 2016a]. Within their boundaries, the latest folding of the thick strata (usually confined to troughs at the outer — oceanic — side of the island), aged from Oligocene to Pliocene, occurred at the Pliocene/Pleistocene interface. It can-

not be ruled out that folding in arcs situated further west is older. In the case of continents, we managed to identify with more certainty zones with prevailing dissimilar endogenous regimes. The relevant data were reported in the authors' earlier publications [Gordienko, Gordienko, 2012, 2015a, b, 2016a—c, 2017a, b, 2018a, b, 2020a, b, 2021; Gordienko et al., 2020 and others].

Fig. 2 shows location of seismic stations whose data were used in this study [International ..., 2014]. The regions covered by studies differ significantly both in terms of the volume of collected evidence (the number of earthquakes) and coverage of the existing structures of the same type. This is associated with the availability of information, as well as with the size and location of the structures. A composite numerical characterization of the data is about 200 seismic stations and 40,000 earthquakes.

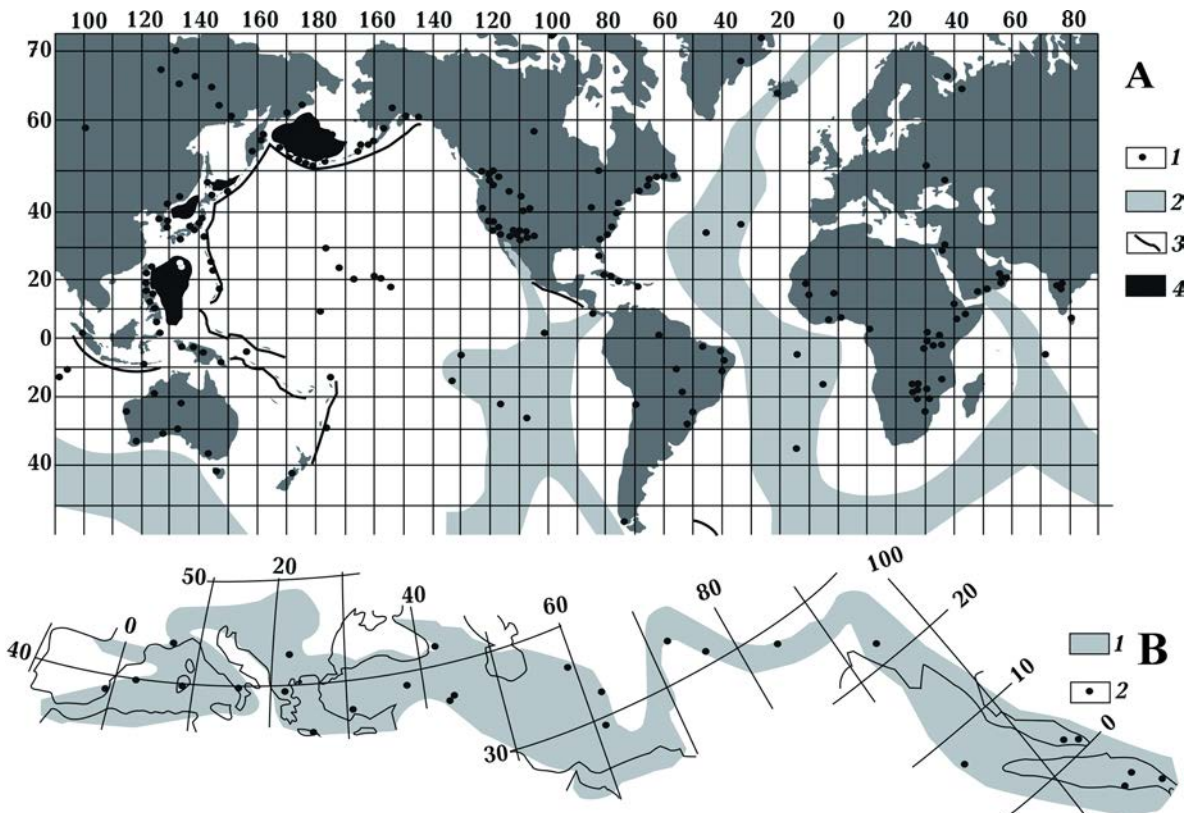


Fig. 2. Seismic stations whose data were used for plotting travel-time graphs.  
 A: 1 — seismic stations, 2 — mid-ocean ridges, 3 — trenches, 4 — back-arc troughs covered by studies.  
 B: 1 — alpine geosyncline Tethis, 2 — seismic stations.

The most comprehensive evidence was collected for island arcs and coastal ridges in the Pacific and Indian oceans. The large spatial extent of the structures and the abundance of earthquakes contributed to our efforts. Trenches, FP and zones of recent activation of platforms were among the least explored objects. The small width of such structures, which are twisted in plan, hampered the choice of sites for seismic recording stations and of shallow earthquakes that might alleviate the construction of a velocity model specifically for the trench not affected by adjacent basins or island arcs. For that reason, the mean velocity model for the trenches turned out to be much less substantiated than for arcs. The maximum depth to which the  $V_p$  pattern was plotted was also smaller. The situation is somewhat better in the case of back-arc troughs: We managed to construct a model for depths reaching the lower portion of the upper mantle. Mid-ocean

ridges are delineated relatively well, while oceanic basins, platforms and rifts — not so well. Hopefully, in the future, the use of larger amounts of data will make it possible to update the so far obtained results. Yet, even the results already at hand may be instrumental in discovering many important characteristics of the mantle's velocity structure beneath regions with different endogenous regimes.

**Computation technique.** The estimated travel-time graph was plotted on the basis of the SEIS-83 modelling program worked out by V. Cerveny and I. Psencik [1984]. Maximum necessary depths that the rays could reach were attained at approximately  $25^\circ$  offset distances and with travel-times of about 300 s (Fig. 3). For comparison with the estimated travel-time graph, we used information on travel-times from a publication by the [International ..., 2014]. We only used those data on the earthquakes whose epicenters were located in

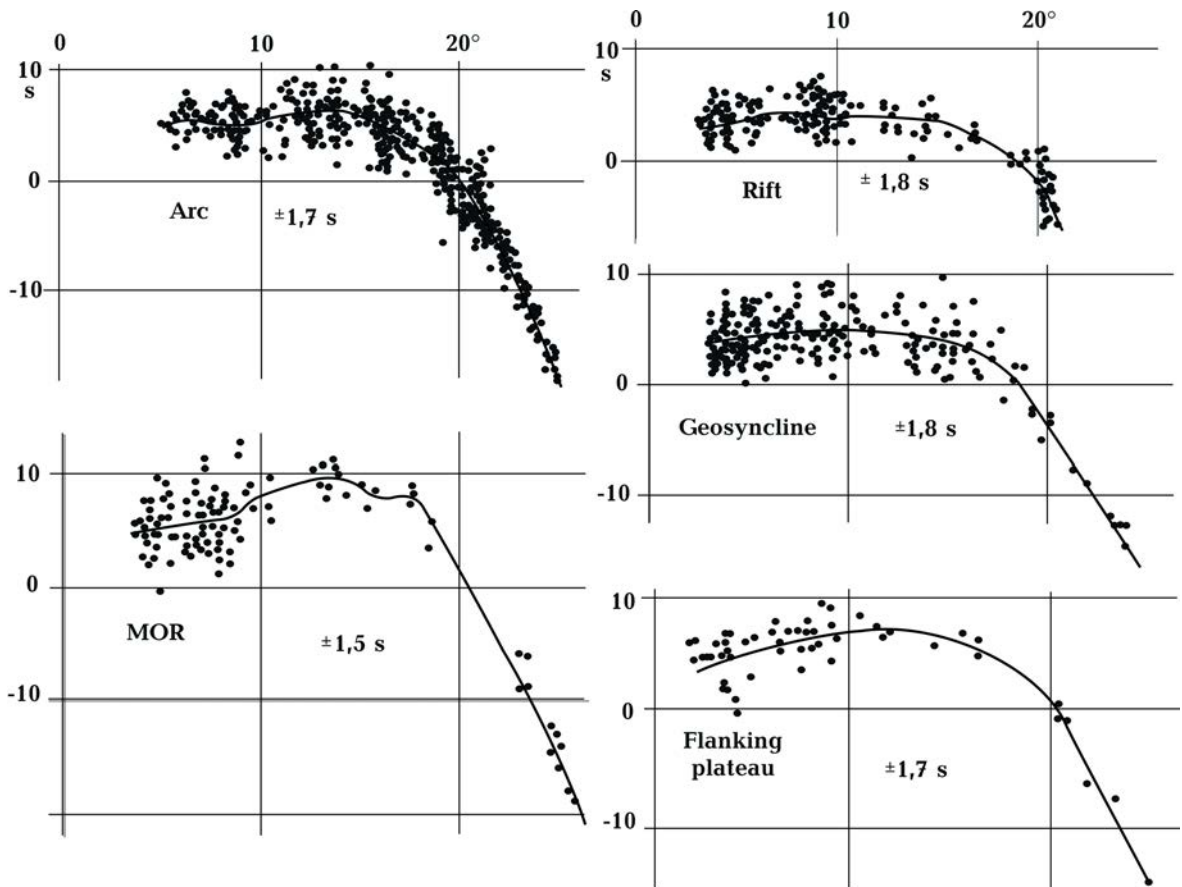


Fig. 3. Reduced observed travel-time graphs recorded at seismic stations in some studied regions.

regions covered by study. The depths ( $H$ ) of the hypocenters used in the analysis of the earthquakes reached 50—55 km. All of them were converted to a single  $H$  value approximately matching the depth of the M discontinuity. Corrections to the arrival times of waves were revised in the process of construction of a velocity structure within the depth range between the actual depth of the hypocenter and the depth of the M discontinuity.

For convenience of comparison between estimated and observed travel-time graphs, we plotted their reduced versions for seismic  $P$ -wave velocities in upper mantle rocks amounting to 8.2 km/s. Smoothing of observed arrival times was performed using a sliding window at 3—4 degrees. The resulting point on the travel-time graph was placed inside the window with an allowance for the varying «cluster» of observed data; a unit step of the window amounted to  $0.4^\circ$ .

Deviation of dots from the median curve appears to be a fairly good characteristic of the error in the observed travel-time graph. The average deviation for all the travel-time graphs is about 2 s. A typical value of the deviations does not exceed those obtained in similar studies [Feng et al., 2007 and others].

Averaged travel-time graphs were constructed for all types of regions under study. Trenches and flanking plateaus were an exception: The insufficient amount of available material caused us to construct a single travel-time graph using the data for all structures. Average deviations of individual travel-time graphs from the median are not large (they reach maximum for island arcs and coastal ridges and continental rifts, but even there they amount to 1.8 s) — just around 1.5 s. At the present level of available information, it is possible to conclude that a single travel-time graph should be applied to the entire dataset for separate structures within regions of the same type. Given the aforementioned errors, differences are inevitable. Results of comparison between observed and estimated travel-time graphs can also be assessed with an account for the aforementioned error. Variations in computation results, expressed in

terms of time differences for dissimilar velocity structures, change significantly with the depth for which changes are introduced into the model.

In order not to overlook velocity anomalies, we will classify as appreciable all those differences between estimated and observed travel-time graphs that exceed two seconds. Yet, not all velocity anomalies (conforming to deviations from the selected estimated travel-time graph) recorded in the procedure can be viewed as reliable.

The majority of observed travel-time graphs match estimated ones fairly well (see Fig. 4 and 5), i. e., we can claim that a typical velocity structure of the upper mantle beneath the features under study matches that used in the computations.

Obviously, the typical differences in the travel-time graphs can be fully accounted for by errors in the source material. Small anomalies (0.10—0.15 km/s), which correspond to differences in wave travel times of 2 s, are not common.

**Discussion of results.** The experimental and estimated velocity profiles differ by an average of  $\pm 0.07$  km/s. This corresponds to the 0.05 km/s error value typical for each of the techniques. In the case of BATs the differences can be 1.5 to 2 times larger. Additional research for those regions is required.

Analysis of the deep-seated processes that prompted the construction of certain thermal models for the mantle and the observed  $V_p$  continues. In this paper, we will focus on velocity models proper.

Velocity patterns that we have constructed comprise symmetrical positive and negative anomalies unlike velocity patterns for parts of quiescent Precambrian platforms (Fig. 6). They point to the advective nature of the heat-and-mass transfer that caused those anomalies. The model for areas beneath trenches and flanking plateaus is an exception. It may well be explained by the lateral aliasing effect on the platform and basin model of overheated volumes of material from the subcrustal mantle beneath island arcs and basins (trenches) and activated basins and MOR (FP). A symmetrical positive anomaly may be positioned

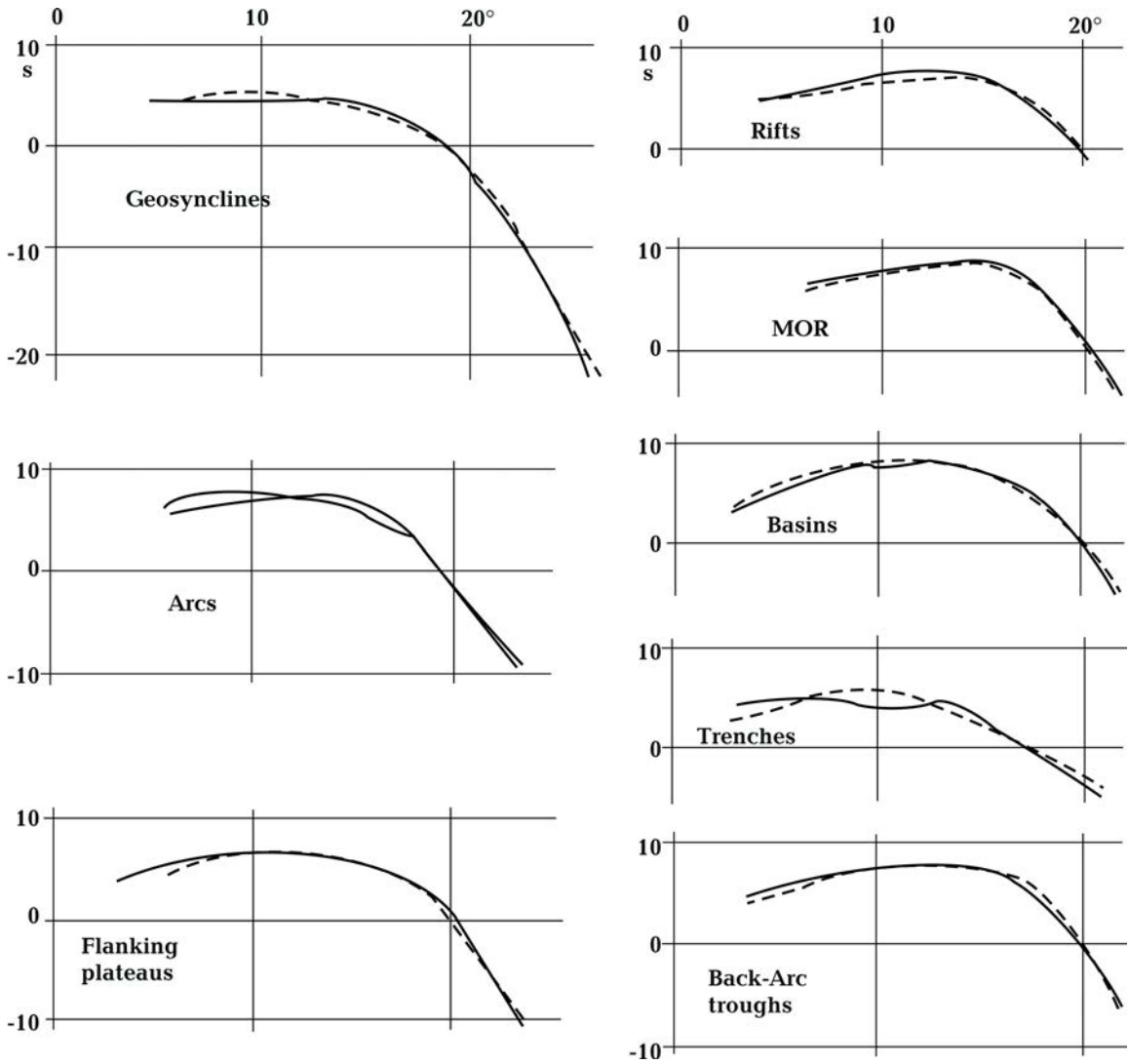


Fig. 4. Coordination between observed (solid lines) and estimated (dashed lines) travel-time graphs.

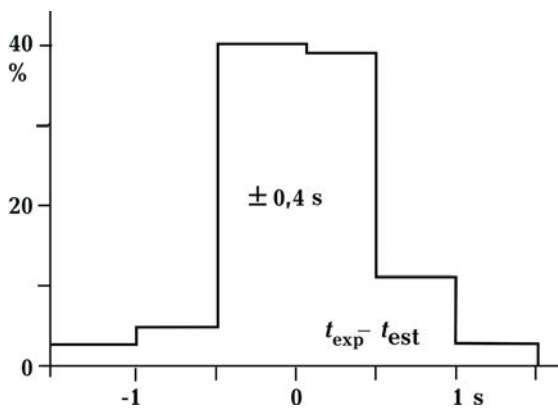


Fig. 5. Histogram showing a pattern of deviations of averaged experimental travel-time graphs from estimated graphs.

at depths larger than those studied beneath trenches. This fact points to a relatively recent large-amplitude advective displacement of the upper mantle material beneath one or both adjacent regions. Geological evidence fully corroborates this assumption. Almost identical heat-and-mass transfer events took place beneath Alpine geosynclines, island arcs, and ocean basins, at any rate in the northwestern Pacific Ocean Basin. 100 million years later, such events took place beneath arcs [Sergeev et al., 1992; Gontovaya, Gordienko, 2006; Gordienko, 2012 and others]. In all cases, they may have been complemented by single-event heat-and-mass transfer processes during recent millions of years. Studies of the upper



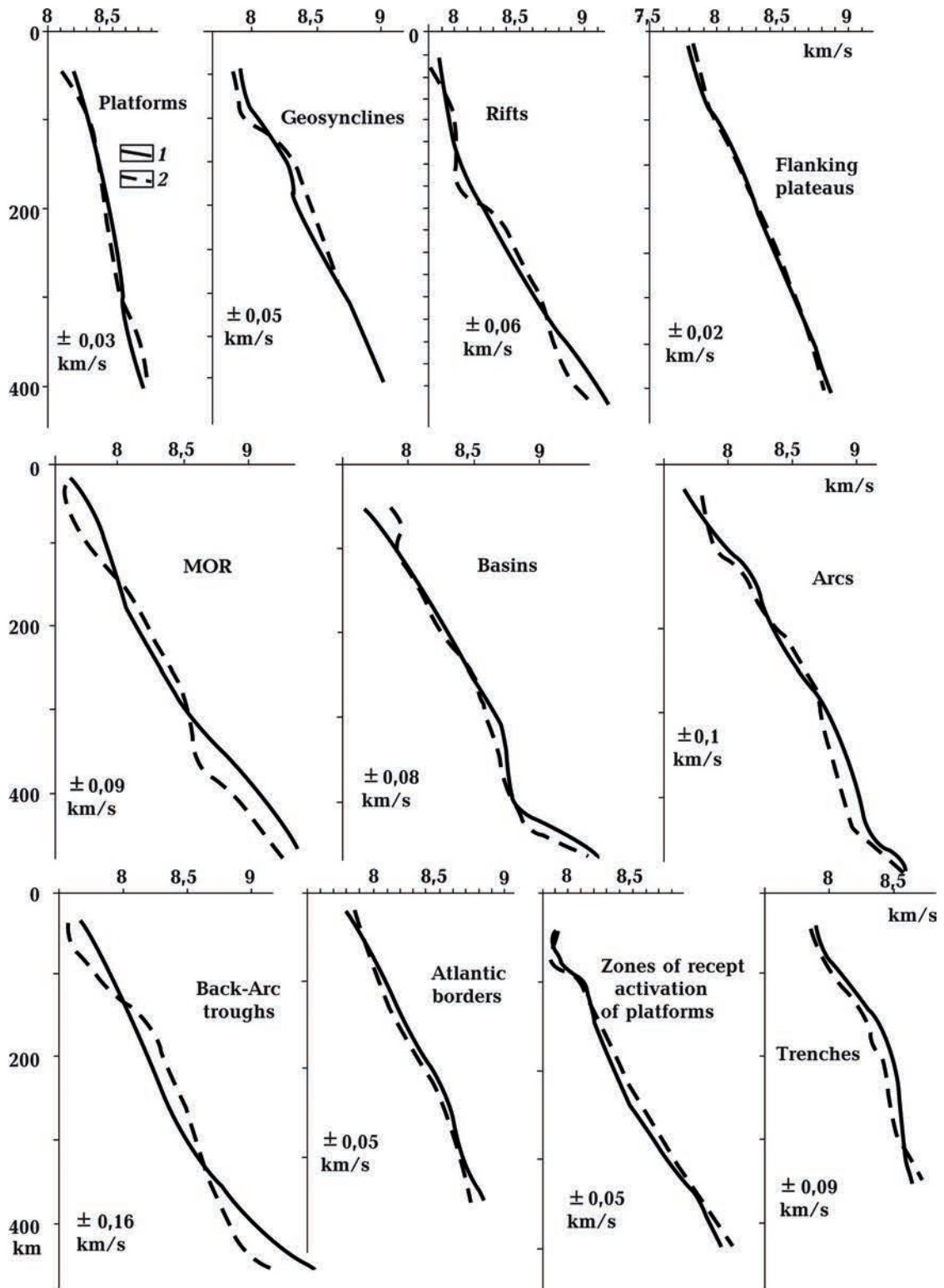


Fig. 6. Best-fit velocity models for the upper mantle beneath the regions with different endogenous regimes. Velocity sections: 1 — observed, 2 — estimated.

mantle beneath trenches at the eastern periphery of the Pacific have not, unfortunately, been conducted.

Velocity structure of the area beneath the trench may point to a relatively small mass of overheated material transported to the sub-

crustal area beneath adjacent regions — at the level of one quantum of tectonic action (QTA). In terms of the advection-polymorphism hypothesis (APH), QTA is the minimum volume of material with a typical diameter of 50–70 km involved in displacement [Gordienko, 2012 and others]. The resulting models have been cross-referenced with  $V_p$  patterns at solidus temperatures and at relevant depths. They differ somewhat for island arcs and coastal ridges, on the one hand, and the rest of the ocean regions, on the other. In the former case, we assumed normal composition of the mantle beneath continents and in other cases, eclogite inclusions most probably underwent melting which caused changes in the solidus temperature and  $V_p$  values. A comparison between the mantle model beneath platforms, trenches, FP and the distribution of  $V_p$  at solidus temperatures prompts a conclusion that there is no asthenosphere there. In all other cases, it does exist, and its top portion lies at relatively shallow depths pointing to the recency of the processes in the mantle. Such depths of the partial-melting layer may only arise under the effect of Alpine or post-Alpine heat-and-mass transfer episodes. Recent post-geosynclinal activation utilizes material and energy reserves of the asthenosphere that emerged precisely at the end of the cycle.

At the very bottom of the profile, the high vertical gradient in the  $V_p$  distribution beneath activation regions may signify the beginning of a polymorphic transformation of the mantle olivine. If one views this anomaly as a consequence of the sharp drop in temperature following the final advective heat-and-mass transfer episode, then the corresponding temperature hike should be at the level of 800 °C. Such an anomaly is unrealistic since it far exceeds the difference between normal platform-type temperatures and the  $PT$ -conditions at the onset of the process of  $\alpha$ -olivine transition into  $\beta$ -olivine. Anyway, a velocity model for such depths is rather dubious: Its noticeable changes do not affect the estimated travel-time graph in any appreciable manner.

Advective transport of the upper mantle material takes place within cells whose centers occur at depths of about 220–230 kilometers. Here  $T$  and  $V_p$  are unchanged. Ex-

ceptions are trenches, Atlantic borders and FP. In these regions  $T$  are created by lateral influences. The average  $V_p$  for the remaining experimental models is  $8.37 \pm 0.07$  km/s, as in the reference models of the upper mantle AK135 or IASP91. There is coordination at a depth of 400 km — about 9 km/s.

**Conclusions.** A rather thick of active regions asthenosphere was detected — a layer of partially molten mantle rocks with a small (approximately up to 2 %) liquid phase content. A thick depth interval of active regions with abnormally low-temperature rocks has been spotted in the lower portion of the upper mantle. The extent of their cooling at the depth of 400–450 km is sufficient for triggering a polymorphic transformation of olivine.

The constructed velocity profiles vary little from region to region with the same type of endogenous regimes. This enables us to maintain that the models represent standard (typical)  $V_p$  distributions in the mantle beneath the regions, just as presumed in terms of the APH. The estimated mantle profile beneath platform, geosyncline, island arc, trench and flanking plateau fully fits that predicted. Models of ocean basins are in agreement with the concept to the effect that the mantle beneath them is a result of smoothing of thermal anomalies that prevailed in the mantle beneath the mid-ocean ridges or back-arc troughs.

A more detailed analysis of the nature of velocity anomalies will be performed in studies of the deep-seated processes in the mantle. Velocity profiles alongside other geophysical information will constitute major criteria for verifying the credibility of the tectogene hypothesis. Upper mantle velocity profiles can be constructed for any region of the Earth with the help of the data reported in the study and with the use of thermal models based on the advection-polymorphism hypothesis (APH). In more detailed studies, they can be used as parameters for constructing «initial reference models» [Kissling et al., 1994, p. 19 635] without the need to restrict the task to focal depths of the earthquakes [Gontovaya, Gordienko, 2006; Gordienko, Gordienko, 2018b].

**Acknowledgements.** The authors wish to express special thanks to Mrs. Rita Schneider for translating this paper from Russian.

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## ***P*-швидкості верхньої мантії**

***V.V. Гордієнко, Л.Я. Гордієнко, 2021***

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Автори побудували моделі, що показують розподіл швидкості сейсмічних *P*-хвиль у верхній мантії під океанічними, континентальними і перехідними регіонами, такими як серединно-океанічні хребти, басейни, жолоби, острівні дуги і задугові западини, атлантичні перехідні зони, флангові плато серединно-океанічних хребтів, платформи, геосинклінали, рифти, зони сучасної активації. Моделі узгоджуються з глибинними процесами в тектоносфері, передбаченими адвекційно-поліморфною гіпотезою. Моделі для районів острівних дуг і прибережних хребтів подібні до моделей для альпійських геосинкліналей, порушених недавньою активізацією. Моделі для районів серединно-океанічних хребтів і задугових западин ідентичні. Вони укладаються в картину сучасного тепломасоперенесення в разі рифтогенезу, який за наявності основної кори континентальної товщини зумовлює океанізацію. Модель для басейну відображає ефект згладжування термічних аномалій під серединно-океанічними хребтами або задуговими западинами приблизно 60 млн років тому. Модель жолобу і флангового плато відображає результат бічного прогрівання верхніх шарів мантії під нерухомим блоком з боку острівної дуги і западини (жолоб), а також серединно-океанічного хребта і западини (флангове плато).

Детальну бібліографію по регіонах, охоплених дослідженнями, наведено у раніших публікаціях авторів за останні вісім років. У публікаціях інших авторів моделі доволі суттєво різняться. Багато в чому це пов'язано з тим, що окремі автори априорі використовують уявлення про швидкісну структуру верхньої мантії.

Високу мінливість швидкостей сейсмічних поздовжніх хвиль у підповерхневому інтервалі глибин виявлено в результаті всіх досить детальних досліджень. Ця мінливість відповідальна за різке збільшення різниці часів приходу хвиль від землетрусів на малих кутових відстанях. Відповідні сегменти годографів ігнорували, і графіки будували приблизно з  $3^\circ$ , після чого розкид часу приходу набував стійкого характеру. Відповідно, профілі швидкості будували, як правило, починаючи з глибин близько 50 км. Побудовані профілі швидкості мало змінюються від регіону до регіону з одним і тим самим типом ендегенних режимів. Це дає змогу стверджувати, що моделі відображають стандартний (типовий) розподіл  $V_p$  у мантії під регіонами, як і передбачалося з позиції теорії.

**Ключові слова:** океани, континенти, перехідні зони, верхня мантія, швидкісні моделі.

## ***P*-скорости верхней мантии**

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Авторы построили модели, показывающие распределение скорости сейсмических *P*-волн в верхней мантии под океаническими, континентальными и переходными регионами, такими как срединно-океанические хребты, бассейны, желоба, островные дуги и задуговые впадины, атлантические переходные зоны, фланговые плато срединно-океанических хребтов, платформы, геосинклинали, рифты, зоны современной активации. Модели согласуются с глубинными процессами в тектоносфере, предсказанными адвекционно-полиморфной гипотезой. Модели для районов островных дуг и прибрежных хребтов аналогичны моделям для альпийских геосинклиналей, нарушенных недавней активацией. Модели для районов срединно-океанических хребтов и задуговых впадин идентичны. Они укладываются в картину современного теплопереноса в случае рифтогенеза, который при наличии основной коры континентальной толщины приводит к океанизации. Модель для бассейна отражает эффект сглаживания термических аномалий под срединно-океаническими хребтами или задуговыми впадинами примерно 60 млн лет спустя. Модель желоба и флангового плато отражает результат бокового нагрева верхних слоев мантии под неподвижным блоком со стороны островной дуги и впадины (желоб), а также срединно-океанического хребта и впадины (фланговое плато).

Подробная библиография по регионам, охваченным исследованиями, была представлена в более ранних публикациях авторов за последние восемь лет. В публикациях других авторов модели однотипных регионов существенно различия. Во многом это связано с тем, что некоторые авторы априори принимают представления о скоростной структуре верхней мантии.

Высокая изменчивость скоростей сейсмических продольных волн в подповерхностном интервале глубин обнаружена в результате всех достаточно детальных исследований. Эта изменчивость ответственна за резкое увеличение разброса времен прихода волн от землетрясений на малых угловых расстояниях. Соответствующие сегменты годографов игнорировались, и графики строились примерно с  $3^\circ$ , после чего разброс времени прихода приобретал устойчивый характер. Соответственно, профили скорости строились, как правило, начиная с глубин около 50 км. Построенные профили скорости мало изменяются от региона к региону с одним и тем же типом эндогенных режимов. Это позволяет утверждать, что модели представляют собой стандартные (типичные) распределения  $V_p$  в мантии под регионами, как и предполагалось с точки зрения теории.

**Ключевые слова:** океаны, континенты, переходные области, верхняя мантия, скоростные модели.